Space Weather Technical Forecast

Issued on Tuesday, 03 January 2023 at 13:28 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of Moderate solar activity throughout. Active electron fluence expected through 03 January, then perhaps slowly declining. Chance of G1/Minor Geomagnetic Storm intervals from later from 03 January to 05 January.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low, with no significant flares from the five regions on the visible disc, all of these evolving slowly. The most active region was AR3180, which produced a series of C-class flares. Remaining regions on the visible disc are all magnetically simple. A region beyond the southeast limb produced a long period C4.0 flare, which has been ongoing since 03/06020 UTC from an active region beyond the southeast limb. This flare was accompanied by a large CME which has been modelled, but is considered unlikely to have an Earth-directed component. No Earth-directed CMEs have been observed on available imagery.

Solar Wind / Geomagnetic Activity: Solar wind speeds observed at L1 has been continuing a declining trend and have now reached 380km/s from 450km/s at the start of the period. Density has been steady at slightly below average levels. Total magnetic field strength was weak throughout, with the north-south component, Bz, also varying weakly. Phi angle was predominantly positive (towards the Sun) but with brief incursions into the negative sector. Geomagnetic activity was mainly Quiet to Unsettled (Kp 1-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at background levels. High energy electron flux (greater than 2MeV) has been at mainly high levels, with a peak of 3550 pfu at 02/1850 UTC. The 24-hour integrated electron fluence has been above the Active threshold throughout. The observed fluence at 02/2359 UTC was 1.6e8 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Mainly Low solar activity is expected, but with an increasing risk of both M-class and X-class flares due to regions beyond the southeastern limb, which are due to become visible from 04 January.

Solar Wind / Geomagnetic Activity: A CME which left the Sun on 30 December, is forecast to arrive during 03 January with a glancing blow possible. Solar wind speeds are expected to rise from background levels on 04 January due to a potential combination of high speed streams from coronal hole 60 and 61 are forecast to connect with the Earth, with estimated speeds in the region of 500km/s. These speeds are then likely to continue through much of 05 and 06 January. Geomagnetic activity is forecast to be mainly Quiet to Unsettled, with a possible increase to Active or G1/Minor Storm levels should the CME arrive. Further G1/Minor Storm levels are possible due to the high speed stream connection on 04 January, with these perhaps continuing into 05 January.

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Met Office Space Weather Technical Forecast

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux observed by GOES-16 is expected to remain at background levels throughout but with a chance of rising alongside any notable flares, giving a very slight chance of exceeding the S1/Minor Storm threshold. High energy electron flux (greater than 2MeV) at GOES-16 are expected to continue at high levels through 03 January, but may be reduced sharply due to the possible CME arrival. Further reductions are possible from 04 January onwards due to the possible effects of the coronal hole high speed stream connections, but there is low confidence in the impact of these effects. Electron fluence levels are expected to remain above the Active threshold on 03 January, but with higher uncertainty from 04 January due to the potential geomagnetic enhancements.

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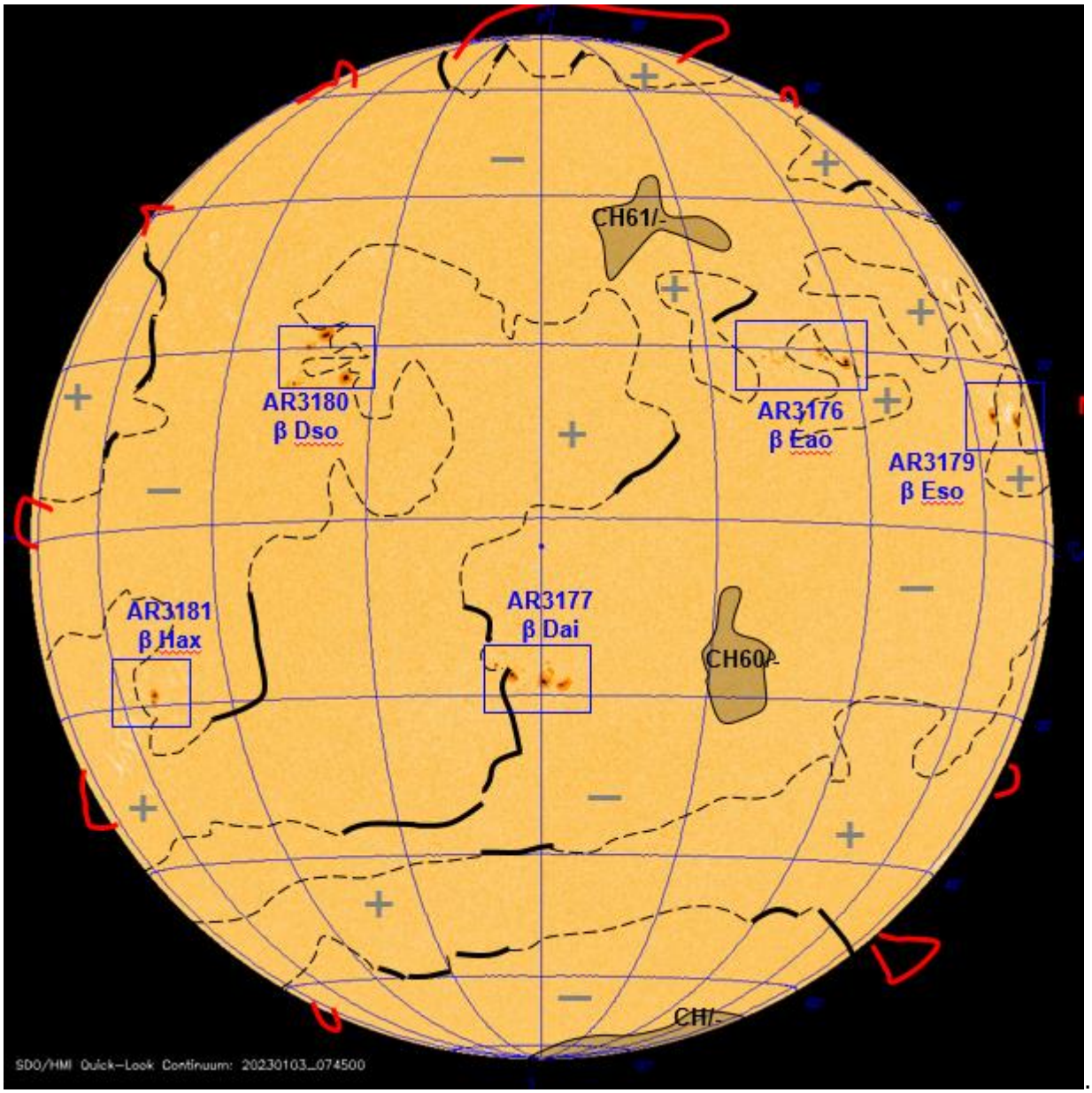
Figure 1. Solar Analysis Valid 03/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME which left the Sun on 30 December is forecast to arrive at Earth on 03 December, but there is low confidence in the arrival time and the level of any impact at Earth. A glancing impact is considered most likely, but there is a probability that the feature may miss the Earth entirely, due to limited data being available for the initial analysis.

The high speed streams from coronal hole 60 and 61 are due to affect the Earth from 04 January, with coronal hole 60 likely to produce a stronger connection due to the relative position of Earth to the coronal hole. Analysis of STEREO-A data suggests that the hole has not yet connected with the spacecraft, suggesting that any connection will be later on 04 January. In the absence of observations for the high speed stream from STEREO-A, speeds of 500km/s are estimated. The effects of the coronal hole are then likely to continue through the remainder of the forecast period.

Geomagnetic activity is forecast to be Quiet to Unsettled, but then with a risk of Active to G1/Minor Storm intervals in the presence of the forecast CME. Further G1/Minor Storm intervals are then possible through 04 and 05 January due to the effects of any high speed stream connection, with a return to Quiet to Unsettled conditions likely by 06 January.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	30	30	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
31/0141	Partial	M1 flare	AR3176	390	Late 03 January	Glancing blow with limited shock likely.

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Figure 2: Recent solar wind parameters

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Radio Blackouts - X-Ray Flares:

Solar activity has been Low over the last 24 hours, with five sunspots on the visible disc. None of these regions have a recent history of M-class flares, with AR3176 producing a C9.4 flare on 02 January. The largest flare of the last 24 hours has been from a region on the far side with a currently ongoing, long period, C-class flare, peaking at C4.0, but with a large portion of the flux obscured by the solar disc. As this region is due to rotate onto the visible disc in the next two days, the risk of both M-class and X-class flares have been maintained at a higher level from 04 January of the forecast period to account for an increased risk.

Low solar activity is expected on 03 January, with an increased chance of M-class and X-class flares from 04 January due to the apparent active regions beyond the eastern limb.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	30	40	40	40
Very Active	R3 to R5 X Class	No	5	10	10	10

Figure 3: GOES 17 electron flux

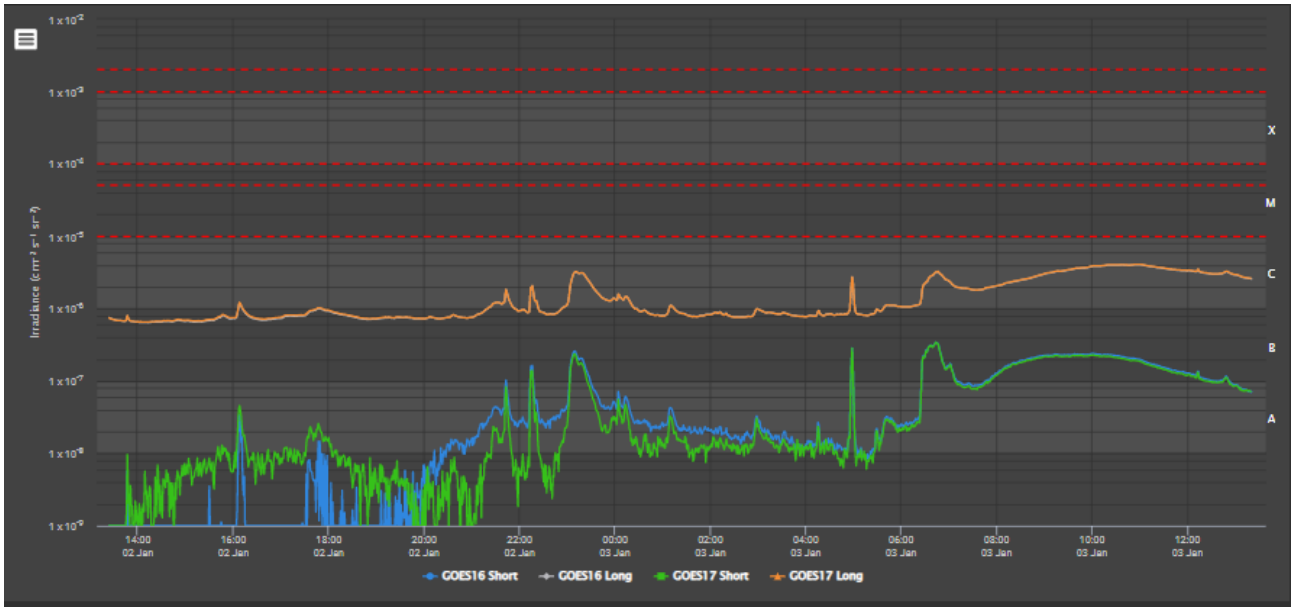

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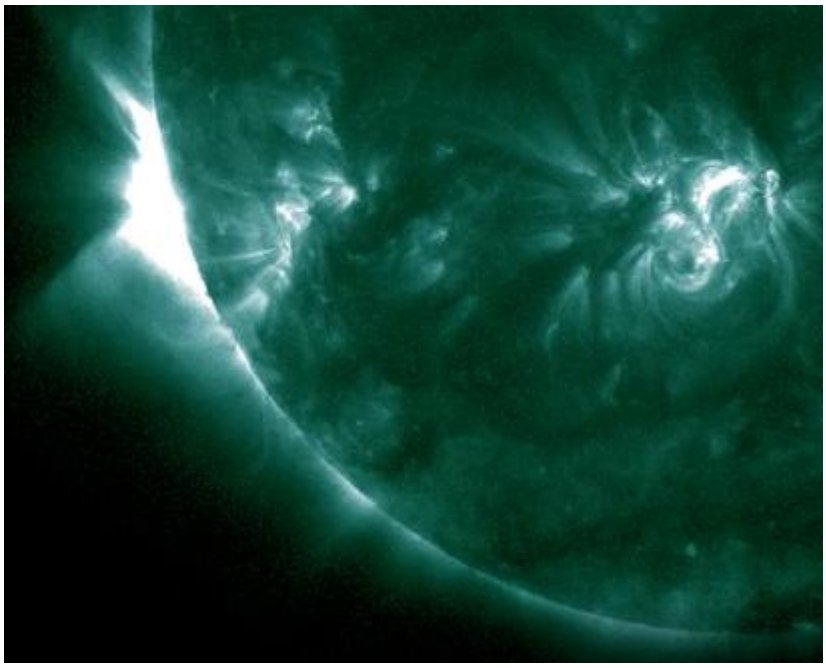
Figure 4: SDO AIA 94 image of long period C-class flare at 03/1106UTC



Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) measured by GOES-16 is at background levels. Any significant flares will bring a risk of proton flux rising at points during the period, with a slight chance of exceeding the S1/Minor Storm threshold. This risk increases through the period, due mainly to the risk presented by the farsided active regions which are just beyond the eastern limb. Despite the position, this region produced a modest increase in electrons following a large CME early on 03 January.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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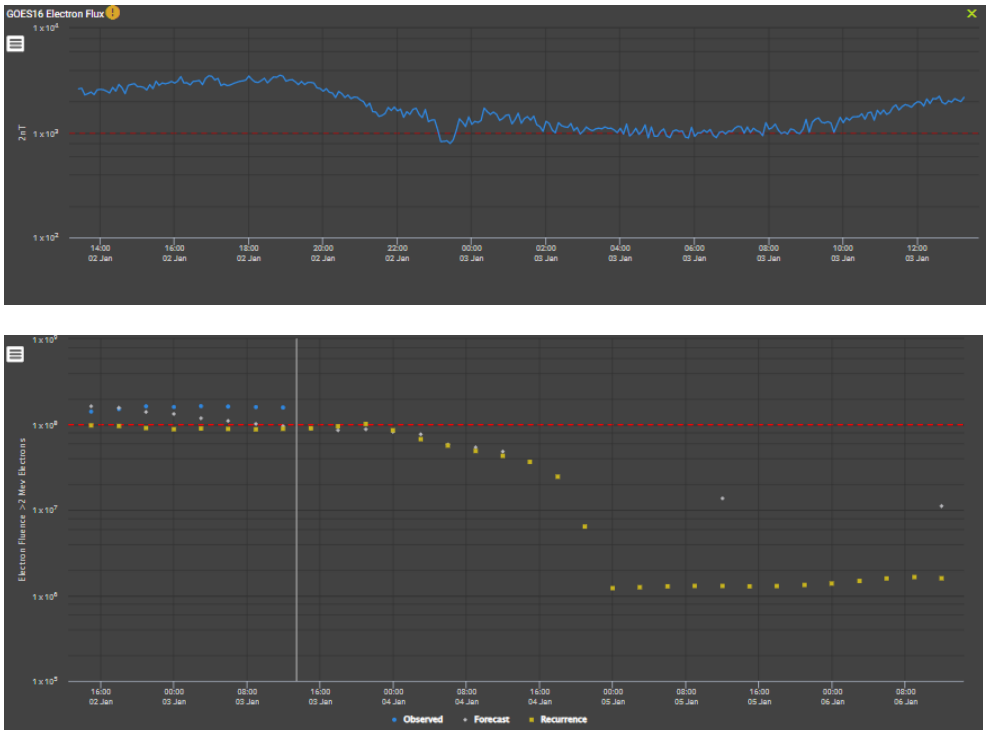
High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) has been oscillating at mainly high levels through the last 24 hours, with this pattern expected to continue through much of 03 January in the absence of any significant geomagnetic activity. The forecast after 03 January is low confidence, as the electron flux could be reduced by the arrival of a CME which left the Sun on 30 December. This may distort the belts and redistribute the electrons, leading to lower electron observations at GEO.

Electron fluence is expected to remain above the Active threshold through 03 January, but will be affected should the flux fall rapidly. There is lower confidence in the fluence forecast from 04 January, as the overall level will be dependent on the balance between the strength of the solar wind and the magnitude of any geomagnetic activity. Based on the low confidence in the CME arrival and forecast potential effects of the coronal hole connections, the forecast is biased toward a continuation of Active electron fluence, but with falling probability through the next four days.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	Yes	100	70	50	50
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: Goes-16 electron flux and MOSWOC REFM model



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